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New records and morphological variation of *Rhadinaea marcellae* Taylor, 1949 (Squamata, Colubridae) from Sierra Madre Oriental, México

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Abstract

Rhadinaea marcellae Taylor, 1949 is known from only 12 specimens. Based on recent fieldwork and research in scientific collections and databases, we report 14 new records of *R. marcellae*, bringing the total number of verified occurrences up to 26, updating our understanding of this secretive species' distribution in the tropical and cloud forests of the Sierra Madre Oriental in Mexico. The new records come from the Mexican states of Hidalgo, Puebla, San Luis Potosí and Veracruz. All the newly reported specimens are morphologically concordant with *R. marcellae*, but exhibit noteworthy variation.

Keywords

Cloud forest, colubrid, morphology, range extension, tropical forest.

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Introduction

The distribution of the genus *Rhadinaea* Cope, 1863 extends from Florida, USA, south to Ecuador, between sea level and around 3200 m elevation, and its members mainly inhabit humid forested regions (Myers 1974). The genus contains 22 species distributed within 6 species groups: the *calligaster* group, *decorata* group, *eduardoi* group, *flavilata* group, *taeniata* group, and *vermiculaticeps* group (Myers 1974, 2011, García-Vázquez et al. 2018, Mata-Silva et al. 2019). The 12 species included in the *decorata* group are found in Mexico and 11 are endemic to the country including *Rhadinaea marcellae* Taylor, 1949. (García-Vázquez et al. 2018). The geographical distribution of *R. marcellae* is poorly understood and contains many apparent gaps. Only 12 specimens are currently known from an altitudinal range between 600 m and 1600 m: the holotype from Xilitla region, San Luis Potosí (Taylor 1949); 1 from eastern Tlanchinol, Hidalgo (Hernández-García and Mendoza-Quijano

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1994); 7 hatchlings from northeast of Tlanchinol; 1 from near Tepango de Rodríguez, Puebla (Nieto Montes de Oca and Mendelson 1997); 1 from Xalpanat, near Cuetzalan, Puebla (Canseco-Márquez et al. 2000); and 1 from Xilitla, San Luis Potosí (García-Vázquez et al. 2018). These records do not necessarily reflect the distribution of *R. marcellae* accurately. Many collectors conduct their surveys at historically well-known sites, at sites of high diversity, or in the most accessible places, producing a bias in distributional information known as the "Wallacean shortfall" (Brown and Lomolino 1998, Lomolino 2004, Reddy and Davalos 2003). Here, we provide new records and data on the geographic distribution and morphological variation of *R. marcellae*, obtained from recent fieldwork and research in scientific collections and databases.

Methods

We collected distribution data for *R. marcellae* from the literature, GBIF database, the VerNet portal and specimens deposited in the collections of the Colección Herpetológica del Museo de Zoología Alfonso L. Herrera, Facultad de ciencias, UNAM (MZFC-HE); Colección Nacional de Anfibios y Reptiles, Instituto de Biología, UNAM (CNAR); Colección Herpetológica del Museo de Zoología, Facultad de Estudios Superiores Zaragoza, UNAM (MZFZ); Colección Herpetológica de la Facultad de Biología: Benemérita Universidad Autónoma de Puebla (EBUAP); Colección de Reptiles del Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Hidalgo (CIB-UAEH); and Herpetological Collection, University of Texas at Arlington (UTA). Additionally, in recent years we conducted fieldwork in tropical and cloud forests as part of herpetological surveys in diverse regions of the Sierra Madre Oriental (SMO), obtaining new specimens and records of *R. marcellae* in addition to those previously reported in the literature. Fieldwork was conducted under the authority of collecting permit FAUT 0243 issued to Uri Omar García Vázquez by the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). We deposited all specimens collected in the field in the Colección Herpetológica del Museo de Zoología, Facultad de Estudios Superiores Zaragoza, UNAM (MZFZ) and photographs were donated to its Digital Collection (MZFZ-IMG). We conducted morphological examinations of the newly reported specimens, measuring the characters used in the diagnosis provided by Nieto Montes de Oca and Mendelson (1997). Terminology of morphological characters follows Myers (1974).

Results

New records. We obtained 9 new records of *R. marcellae* during fieldwork, additionally 5 not previously reported specimens were found in herpetological collections. The numbers that precede each locality serve as reference for Figure 1.

MÉXICO: **San Luis Potosí**: (**1**) Xilitla: La Silleta

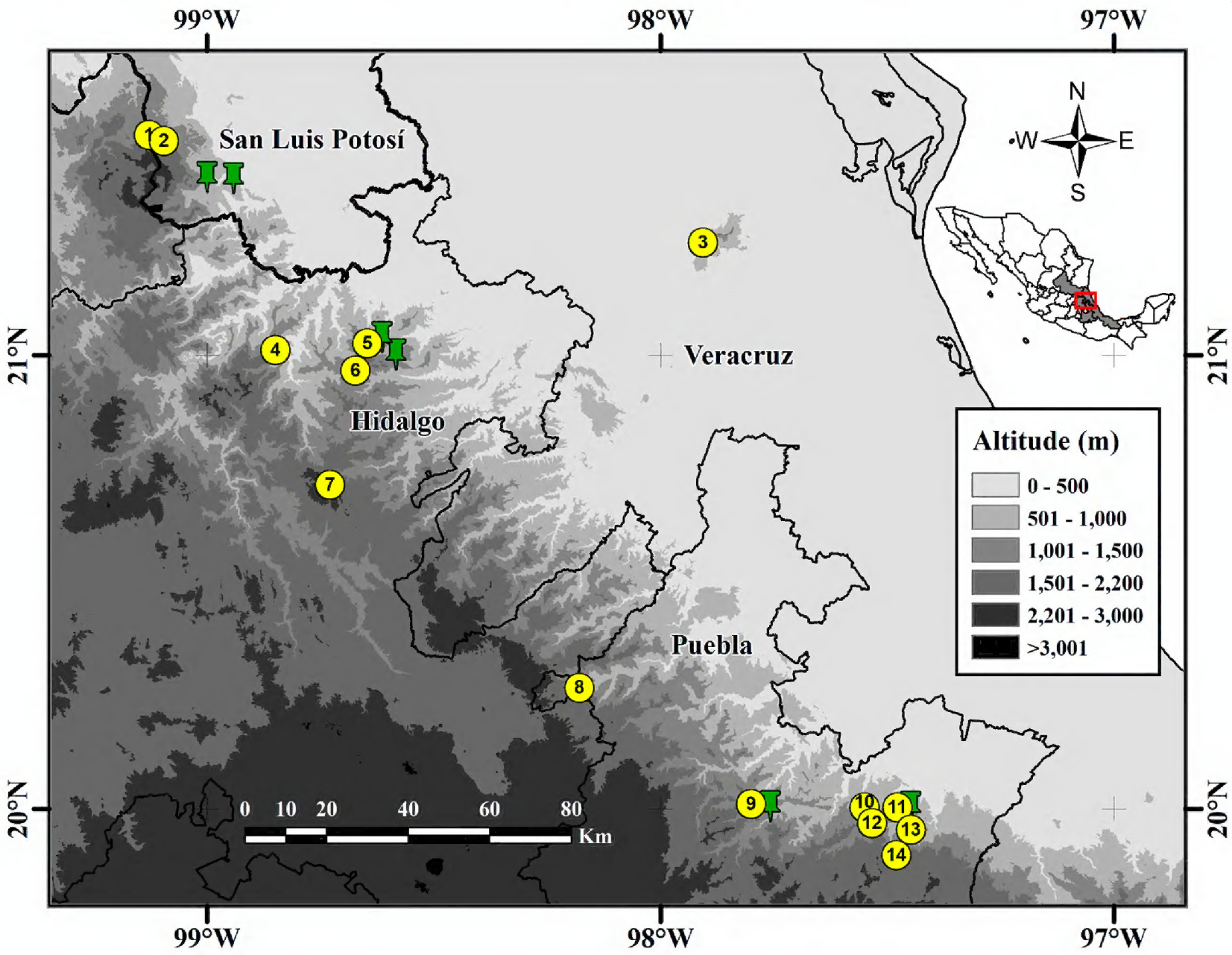

Figure 1. Records of *Rhadinaea marcellae*. Green pins represent literature records and yellow dots represent new locality records. Numbers indicate the locality and correspond to the Results section.

(21°26.72′N, 099°03.75′W; 1520 m elev.), Juan Cruzado Cortés, 2 Dec. 2017 (MZFZ-IMG 182). (**2**) Xilitla: La Silleta (21°26.48′N, 099°03.74′W; 1770 m elev.), Juan Cruzado Cortés, 12 Nov. 2017 (MZFZ-IMG 181). **Veracruz**: (**3**) Chontla: Ejido San Nicolasillo (21°14.9′N, 097°54.62′W; ca 1060 m elev.), Juan Carlos Sánchez García and Uri Omar Garcia Vázquez, 13 Aug. 2016 (MZFZ 3732). **Hidalgo**: (**4**) Tepehuacán de Guerrero: Xilipa (21°6.67′N, 098°46.67′W; ca 1080 m elev.), Luis M. Badillo Saldaña, 23 Sept. 2011 (UAEH uncataloged). (**5**) Municipality of Tlanchinol: La Cabana (21°1.57′N, 098°38.76′W; ca 1540 m elev.), Fernando Mendoza Quijano, 6 Dec. 2004 (UTA 53042). (**6**) Near Tlanchinol (20°57.94′N, 098°40.37′W; ca 1120 m elev.), Juan Carlos Sánchez García and Uri Omar García Vázquez, 10 Jun. 2016 (MZFZ-IMG 183). (**7**) Approx. 10 km NE Metztitlán (20°42.82′N, 098°43.73′W; 1800 m elev.), Oscar Flores Villela, 24 Sept. 2016 (MZFC-HE 31339). **Puebla**: (**8**) Near Pahuatlán (20°16′N, 098°10.73′W; ca 1930 m elev.), Luis Canseco Márquez, 12 Aug. 2012 (MZFZ 3733). (**9**) Tepango de Rodríguez (20°0.6′N, 097°48′W; ca 1560 m elev.), Abraham Avila Soriano, 30 Aug. 1985 (CNAR 6895). (**10**) Cuetzalan: 4 km SE San Miguel Tzinacapan (20°0.18′N, 097°33′W; ca 1160 m elev.), Luis Canseco Márquez, 26 Apr. 1998 (EBUAP 1592). (**11**) Cuetzalan: Xalpanat (20°0.18′N, 097°28.13′W; ca 910 m elev.), Luis Canseco Márquez, 28 May 1998 (EBUAP 1582). (**12**) Ca 5 km S Cuetzalan (19°58.1′N, 097°32′W; ca 1220 m elev.), Luis Canseco Márquez, 3 Aug. 1998 (EBUAP 1593). (**13**) Ca 8 km N Hueyapan (19°57.21′N, 097°26.86′W; ca 770 m elev.), Uri Omar García Vázquez, 28 Oct. 2010 (MZFZ 3731). (**14**) Tlatlauquitepec: Xocayucan (19°53.86′N, 097°28.81′W; ca 1540 m elev.), Uri Omar García Vázquez, 28 Mar. 2010 (MZFC-HE 24585).

Identification. The dorsal base color in most of the specimens assigned herein to *Rhadinaea marcellae* is dark brown, and the vent is cream-brown, all specimens have a pale, declined postocular line projecting to behind the corner of the mouth and a dark vertebral line formed by dark bordered scales with a pale center, and a series of light spots forming a narrow dorsolateral light line. However, all the examined specimens are consistent in having 1 preocular, 2 postoculars, and dorsal scales in 17-17-17 rows, with the exception of the voucher MZFZ 3733 from Pahuatlán, because this specimen was found on the road in a very poor condition and recovery of this morphological information was impossible. Of the 14 specimens, 7 differ from the holotype in nuchal coloration: 3 (MZFZ 3733, EBUAP 1582 and MZFC 24585) present a broken, incomplete collar; 4 (EBUAP 1592, EBUAP 1593, MZFZ-IMG 182 and the uncatalogued UAEH specimen of Hidalgo; Fig. 2A) have an incomplete collar formed by a narrow vertebral line with flaps that extend laterally towards the postocular lines without contacting them or only have a narrow vertebral line without lateral extensions, similar to the specimen from near Tepango reported by Nieto Montes de Oca and Mendelson (1997). The remaining vouchers display a complete collar concordant with holotype (Tylor 1949) such as the Voucher: UTA 53044 (Fig. 2B), with the exception of the specimens from Metztitlán (MZFC-HE 31339) and Chontla (MZFZ 3732; Fig. 2C) that present a wider collar of about 2 scales. On the other hand, variation exists in the width of the lateral dark lines among the specimens. This line principally occupies the fourth dorsal scale row, but the width differs between one-fifth to one-half of a scale row. The full morphological measurements and scale counts of the revised specimens are shown in Table 1.

Discussion

All records of *Rhadinaea marcellae* that have vegetation data come from cloud forest or medium tropical semideciduous forest, at an altitude range from 700 to 1920 m. Myers (1974) suggested that the habitat of *R. marcellae* is limited only to cloud forest, and suggested that the holotype was probably collected in the mountainous region of Xilitla, San Luis Potosí, where altitude goes from 600 m to above 2100 m. This assumption had not been corroborated previously, however the records from the locality known as "La Silleta", located in the north of Xilitla (MZFZ-IMG 181–182) are from cloud forest at altitudes of 1520 m and 1577 m. Also the specimen MZFZ 3730, previously reported by García-Vázquez et al. (2018) as "ANMO 4339" (Fig. 2D) was collected at 706 m altitude in a relic of tropical forest, in the vicinity of the town of Xilitla.

The specimen MZFZ 3732 was collected in an ecotone of medium tropical forest and cloud forest in the Área Natural Protegida "Sierra de Otontepec", Municipality of Chontla, and represents the first record of *R. marcellae* for the state of Veracruz, extending the distribution of the species 75 km NE from the closest locality, in Tlanchinol, Hidalgo, and 115 km SE of the type locality in San Luis Potosí. Seven records correspond to Puebla state and come from the Municipalities of Tepango de Rodríguez (CNAR 6895), Cuetzalan del Progreso (EBUAP 1582, EBUAP 1592, EBUAP 1593), Hueyapan (MZFZ 3731; Fig. 2E), Tlatlauquitepec (MZFC-HE 24585), and Pahuatlán (MZFZ 3733). The locality of Tlatlauquitepec likely represents the southernmost limit of the species. The specimen from the municipality of Metztitlán (MZFC 31340) extends the known distribution in the state of Hidalgo 38 km to the south.

The distribution of *R. marcellae* along the Sierra Madre Oriental (SMO) appears to be fragmented, but this is likely caused by sampling gaps. There are approximately 75 km between Tepehuacán, Hidalgo, and Pahuatlán, Puebla, and 80 km between Tepango, Puebla, and the closest records. These gaps have areas with slightly variable conditions that seem appropriate for this species to live in, with altitudes from 500 m to 1500 m, a semi-warm humid climate with patches of tropical forest, cloud forest, or oak forest in the higher elevations,

Figure 2. Specimens of *Rhadinaea marcellae* in life. **A.** UAEH unacatalogued; Tepehuacan de Guerrero, Hidalgo. **B.** UTA 53042; Tlanchinol, Hidalgo. **C.** MZFZ 3732; Chontla, Veracruz. **D.** MZFZ 3730; Xilitla, San Luis Potosí. **E.** MZFZ 3731; Hueyapan, Puebla.

separated from each other by induced grasslands, roads, and human settlements (Martínez et al. 2007, Nieto and Escandón 2010). It is necessary to increase collecting effort in these regions in order to verify the presence of *R. marcellae*. On the other hand, the locality of the Sierra de Otontepec has similar conditions to those of the nearest localities in the SMO, but it is isolated from these records by the coastal plain of the Golfo de México, a low elevation region (less than 300 m) with large areas of induced pasture and patches of secondary vegetation. However, the specimen from the Sierra de Otontepec has morphological characteristics that agree with the diagnosis of *R. marcellae* (Taylor 1949, Myers 1974, Nieto Montes de Oca and Mendelson 1997). According to this information, it seems unlikely that *R. marcellae* could be distributed continuously between the SMO and the Sierra de Otontepec, therefore it is necessary to carry out fieldwork in the coastal plain of the Golfo de México to verify if there are populations of *R. marcellae* in this intermediate zone.

Table 1. Morphological characteristics of the specimens examined. SVL = snout-vent length (mm); TL = tail length (mm); Ven = number of ventrals; Sub = number of subcaudals; Sup = number of supralabials; Inf = number of infralabials; Subp = number of subpreoculars.

Specimen	SVL	TL	TL/SVL (%)	Ven	Sub	Sup	Inf	Subp	Collar
MZFZ 3730	151	73	48.3	139	75	8-8	10-10	0-0	Complete
MZFZ 3732	197	92	46.7	130	71	8-8	10-10	1-1	Complete
MZFC 31339	211	90	42.7	135	69	8-8	10-10	0-0	Complete
UAEH uncatalogued	295	133	45.1	145	72	8-8	10-10	0-0	Vestigial
MZFZ 3731	270	126	46.7	132	71	8-8	10-10	1-1	Complete
EBUAP 1582	141	68	48.2	125	73	8-8	9-9	0-0	Incomplete
EBUAP 1592	223	75	33.6	136	50	8-8	9-9	1-1	Vestigial
EBUAP 1593	202	97	48.0	130	67	?-8	?-11	?-1	Vestigial
CNAR 6895	105	43	41.0	123	69	8-8	10-10	0-0	Complete
MZFC 24585	97	41	42.3	131	74	8-8	9-10	1-1	Incomplete

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Authors' Contributions

All the authors conducted fieldwork, collected specimens, participated in writing, and contributed data and photo vouchers; JCSG, UOGV, and CJPV led writing; JCSG compiled the database, made the literature review, and designed the map.

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